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LS-30

Low Noise Switch

+/-15V Range

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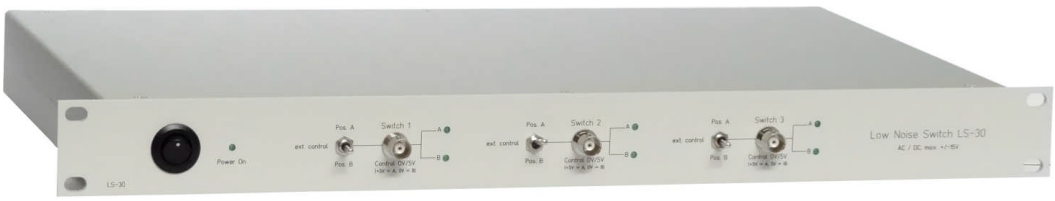

Data Sheet & User Manual

Rev. 1.2

Model Number LS-30 Triple

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1. Safety Hints

Read all installation, operation, and safety instructions	Prior to operation, thoroughly review all safety, installation, and operating instructions accompanying this equipment.
Rear side switch turns device completely off	If the device is not in use for a longer time, it is recommended to turn the mains switch at rear side off.
This equipment must be connected to an earth safety ground	This product is grounded through the grounding conductor of the power cord. To avoid electrical hazard, the grounding conductor must be connected to protective earth ground.
Do not modify the unit	Do not make electrical or mechanical modifications to this unit.
Change cabling only when device is off	Changing the cabling, when voltages are present at the outputs can lead to formation of harmful sparks.
Do not operate in wet/damp conditions	To avoid electric shock hazard, do not operate this product in wet or damp conditions. Protect the device from humidity and direct water contact.
Beware of external magnetic fields	External magnetic fields can impair, damage or even destroy this device. A maximum external field strength of no more than B = 10mT is admissible. Having placed the device at any time into an external magnetic of bigger B = 10mT (regardless if power was turned on or off) can lead to severe overheating of the device and severely increased hazard of fire.
Service is to be performed by qualified service persons only	All servicing on this equipment must be carried out by factory-qualified service personnel only.
Do not block chassis ventilation openings	Slots and openings in the chassis are provided for ventilation purposes to prevent overheating of the equipment and must not be restricted. All case vents should continuously be cleared (fan inlet at rear side, air outlet at rear side), in order to prevent overheating.
Routinely cleaning from dust	After long operation, or operation in a dusty environment it is strongly recommended to have the internal parts of the device cleaned by the manufacturer, or an appropriately qualified workshop in order to reduce the hazard of overheating.
No outdoor operation	Outdoor operation of the device is not admissible.

2. General Information and Overview

2.1 Purpose and Description of the Device

Purpose of the LS-30 devices is the fast switching of electrodes, electrostatic lenses, beam deflectors or ion traps. Unlike DC *power* switches, the outputs expect capacitive loads in the 100pF range. The outputs are optimized for high stability and very low noise. The switches are housed in standard 19-inch rack-mount cases. They are available in single-channel to triple channels versions. Individual switches are completely independent except that they share a common GND.

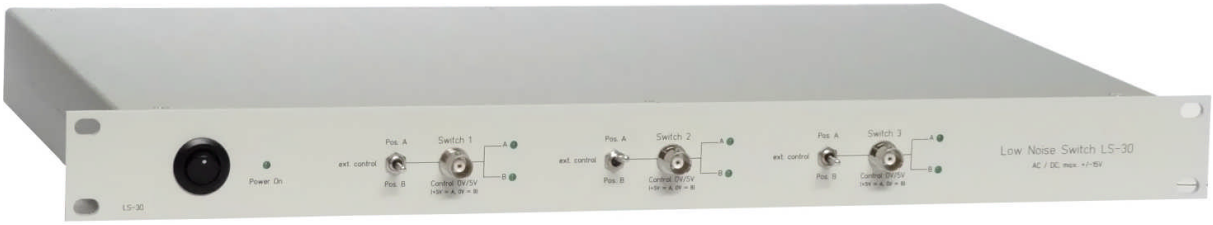

fig 2.1: front view of a LS-30 device (triple version)

2.2 Functional Principle and Block Diagram

The following scheme displays a block diagram of the internal structure and illustrates the functional principle. The control input (BNC socket on front plate) defines the position of the internal high voltage switch, which connects either input A or input B to the output. A digital signal (TTL/CMOS level 0V/5V) may be applied to this control input. A three-position manual switch on the front side allows to override the digital control signal. The switching elements inside the device are implemented as MOSFET-transistors, allowing fast switching transitions in the order of 20ns and less.

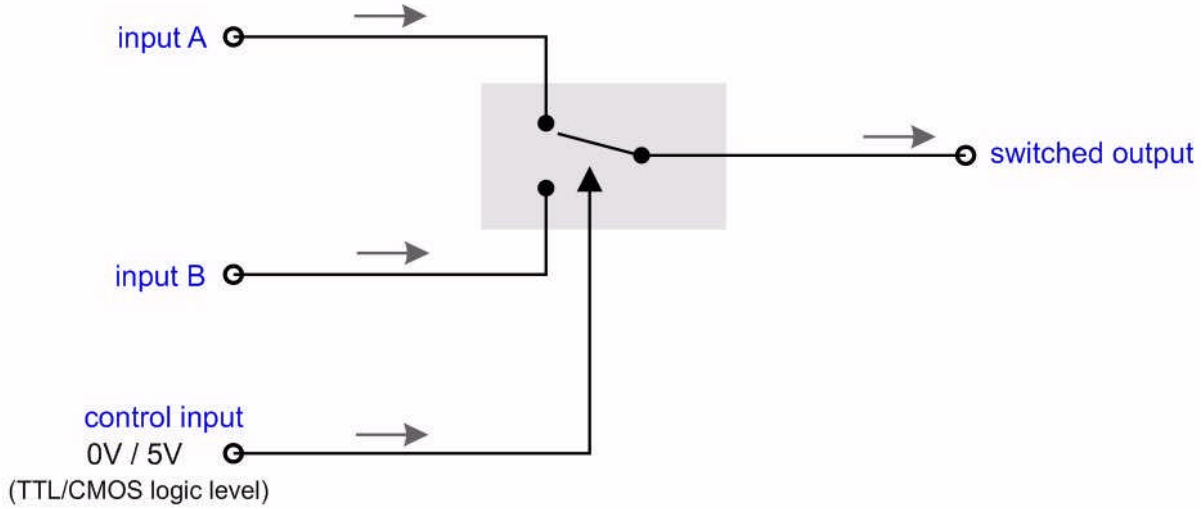

fig 2.2: Block diagram of a LS-30 device. Inside the triple version, the scheme exists three times, i.e. there are three independent switches.

Unlike high voltage pulse-generators the internal switch circuitry is implemented as fast static switch, which means that the applied control input level defines the (static) switch position as illustrated in the scheme above. The output is connected to the selected input by a (transistor based) resistor. The non-selected input is isolated from the output by a high isolation resistance.
The input range for both inputs A and B is -15V to +15V each. Either polarity is applicable. In case the latter voltage is exceeded for a short time, it will be clamped to approx. +/-16V. Note that voltages

being substantially higher that +/-15V, which are permanently applied to an input or output, will damage the device.

Application example:
Generation of 500µs-duration positive-going 30Volt-pulse

The subsequent oscilloscope screen shot shows a typical application example. A control pulse of logic level (high = 5V, low = 0V) is applied to the control input. Inputs B and A were provided with an external voltage of -15V and +15V respectively. At the edges of the control signal the switch is triggered, and switches from -15V to +15V and after 500µs back to -15V. Trace 2 shows the control signal, being used to trigger the switch. A rectangular pulse results, with steep slopes and constant-voltage static levels. For further details on the slope of the waveforms see section 4.3

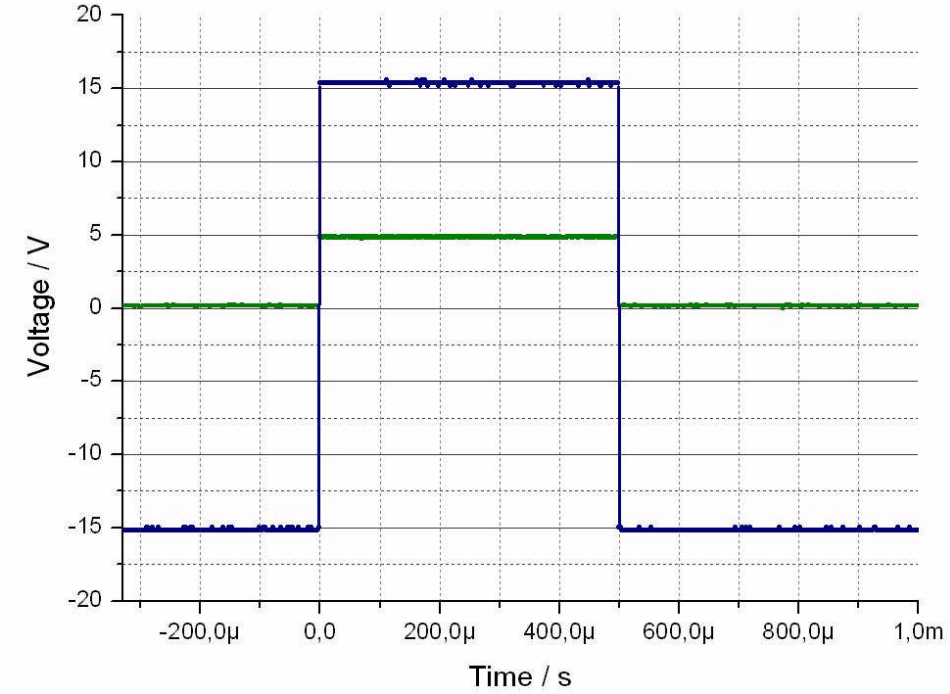

fig 2.3: Oscilloscope traces of a positive pulse, Δt = 500µs duration.
The green trace shows the digital control signal, the blue shows the output signal.
Oscilloscope: Rigol DS1302 CA, capacitive load: 100pF

3. Installation

3.1. Mechanical and Electrical Installation

Positioning: Provide sufficient air cooling of the device and locate it in normal horizontal position to allow for defined air convection. Rack mounting into a standard 19" rack is possible as well as resting the device on a table. If mounted in a rack, please make sure that all case vents are permanently cleared (fan inlet at rear side, air outlets at rear side), in order to prevent overheating.

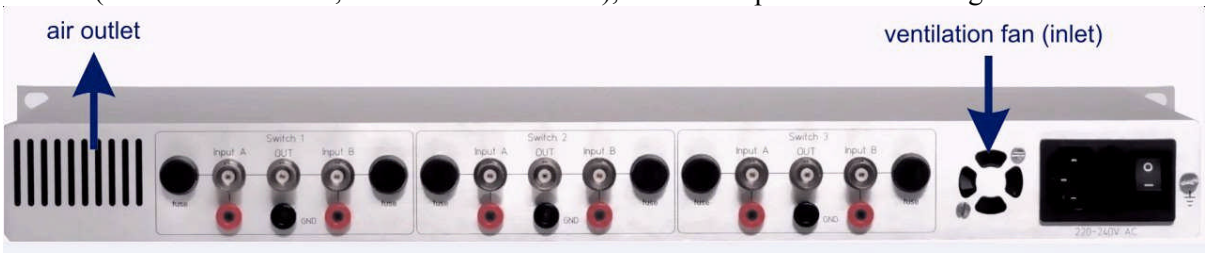

fig. 3.1: Keep air vents always cleared to ensure sufficient ventilation

Beware of external magnetic fields:
Strong external magnetic fields can impair, damage or even destroy this device (e.g. proximity to a superconducting magnet). A maximum external field strength of no more than B = 10mT is admissible. Not observing this important limit can lead to severe overheating of the device and increases the hazard of fire.

Connecting to mains power:
Connect the device to the mains power supply (220 to 240V ac) by using an appropriate power cord, being properly wired and providing a grounded outlet. The power cord must be suited with respect to possible load currents and should be rated to 2A current.

Cabling of voltage outputs:
Always provide appropriate and safe cabling when connecting the device to other devices or vacuum/experimental setups. Cabling is preferred using coaxial cable with proper shielding. BNC connector cables are a suitable choice in order to ensure proper shielding against external noise pickup and in order to provide protective ground for safety reasons.

4. Operation and Control Elements

4.1 Elements on the front plate

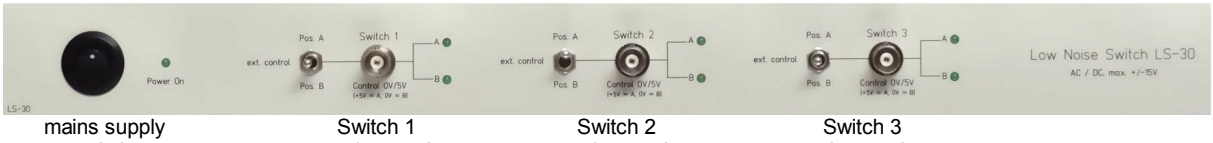

fig. 4.1: front plate elements

The front plate contains the control elements of the device. It is powered up after turning on the rear-side mains supply switch and also the power button on the front plate. The Power-on-LED (green) indicates proper operation of the internal circuitry.

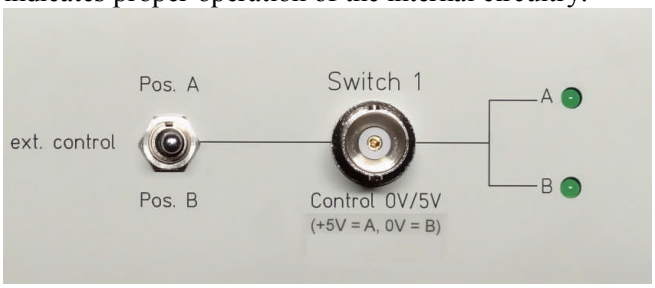

fig. 4.2: manual switch, BNC input and LED indicators.

Each channel features a three-position manual switch (fig. 4.2). Lifted upwards, the output (rear side) is connected to the input A, moved into lower position it connects the output to input B. In the center position of this switch the control voltage, being applied to the BNC input, defines the switch position. A high level connects the output with A, low level connects to B. Common 5V / 0V signal may be applied to this BNC control input. In practical cases a PC controlled Delay-Gate generator or function generator is often connected to this BNC input. The LS-30 device is rated for input voltages (inputs A and B up to +/-15V DC vs. GND)
The LED indicators on the right hand side show the switch status, indicating which input (A or B) is connected to the output.

4.2 Elements on the rear side

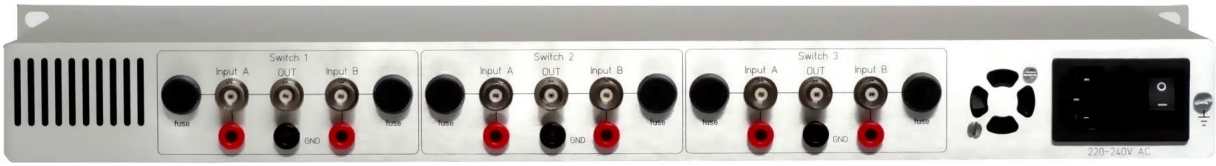

fig. 4.3: rear side elements (a triple channel version is shown)

The rear side of the device contains the ventilation elements, 230V supply connector, power on/off switch (with fuses) and the switch inputs and outputs.

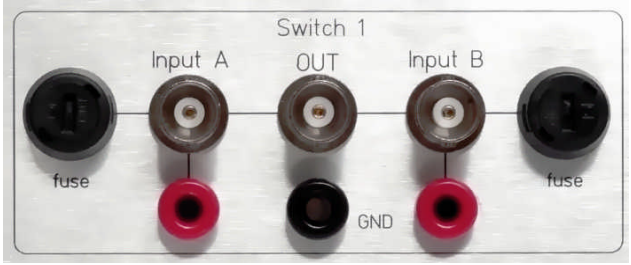

fig. 4.4: BNC and 4mm sockets for inputs and BNC output, fuse sockets

Fig. 4.4 shows the BNC sockets for the two input voltages A, and B and the switch output OUT. Alternatively the input voltages can be applied to the two red 4mm laboratory sockets, for which the black center socket serves as GND input. The fuse sockets shown in fig. 4.4 contain safety fuses for the two inputs. In case extensive currents flow, they may blow. Nominal rating is 0.5 Ampere, fast blow. All voltages must reside in the interval between -15V and +15V to avoid damage to the device.

Please note that the capacitive load on the output may impair the switching speed performance. Nominal loads from 0pF to 300pF may be connected. See also next section for waveforms traces.

4.3 Output Characteristics

Dynamic Response

As soon as the internal switch connects either input A or B to the output, the latter assumes the voltage on the respective input. There is a time constant related to each voltage transition, essentially given by the internal switch resistance (approx. 150 Ω), the internal output current limit (approx. ±250mA) and the capacitive load on the output, including all cables to an experimental setup. In case of BNC cables one may count about 100pF per meter cable length, therefore extensively long cables should be avoided.

The following oscilloscope traces show voltage step transitions observed at the output with a medium capacitive load (100pF) for further illustration.

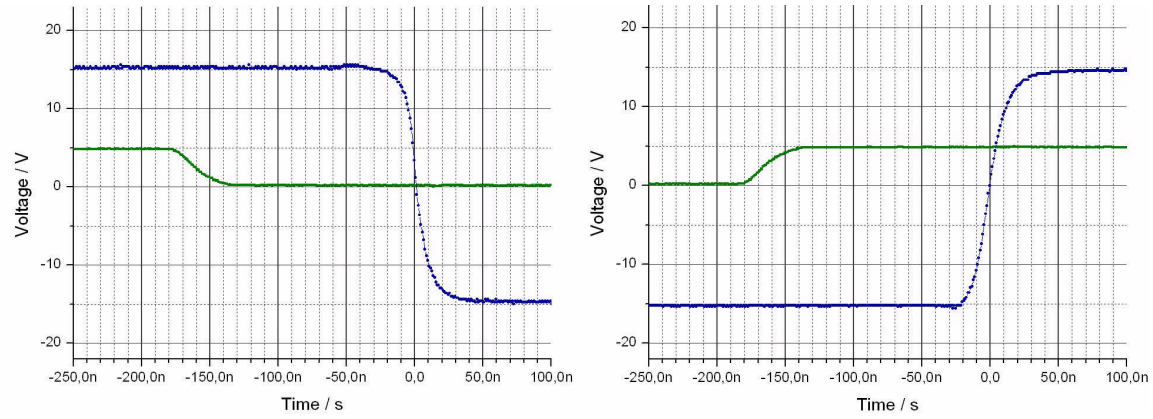

fig. 4.5 (left frame) negative voltage step of 30V from +15V to -15V with medium capacitive load (C = 100pF) at the output; (right frame) positive voltage step of 30V with the same capacitive load; transient rise time (10% to 90% of voltage step size) is in the order of 22ns in each case. Oscilloscope: Rigol DS1302 CA, 300MHz bandwidth. Green trace: control signal; blue trace: output signal.

Noise and Ripple

In contrast to other devices, based on switched circuit / power switching technology, the HS series devices feature a very low noise level. This makes them specially suited for ion traps, low energy beam line applications or medical sensors. Each output exhibits a very low broadband noise (DC to 20MHz) of smaller than $5\mu V_{rms}$ and a low ripple level (50Hz) in the order of $4\mu V_{rms}$. In general the outputs are completely free of parasitic switching spikes in the RF region. The subsequent graphs show further details regarding observed waveforms and noise densities.

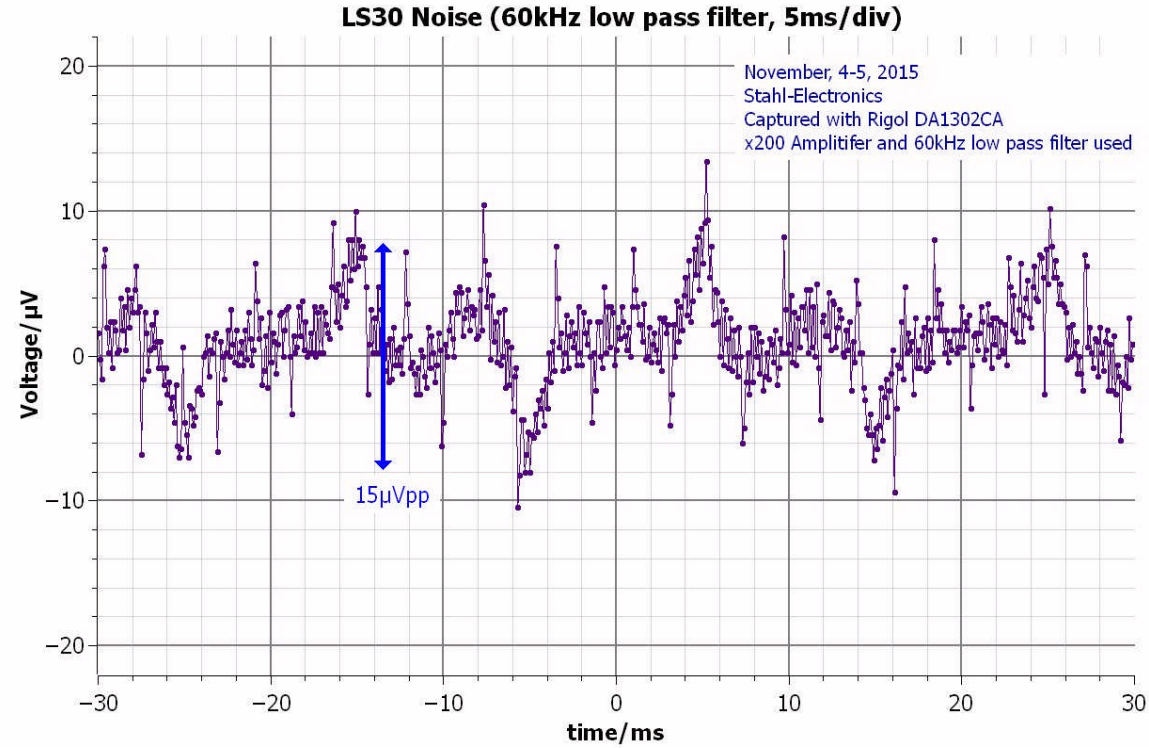

fig. 4.6: Output signal being observed using a 200V/V preamplifier and digital oscilloscope, while input being switched to GND. A statistical signal is visible and an additional 50Hz Ripple of about 4µVrms, or 15µVpp. A 60kHz low pass filter was used to define the frequency window of this measurement (i.e. DC to 60kHz). The displayed span on Y-axis is 42µV.

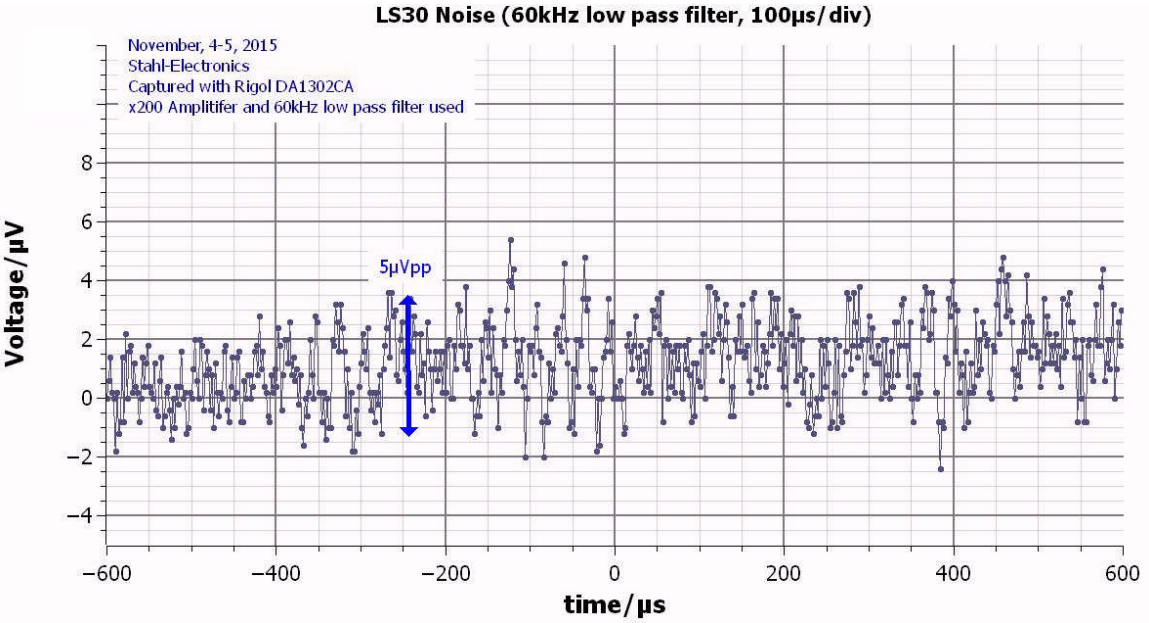

fig. 4.7: Recorded trace of same configuration as in figure 4.6, but faster time scale. A statistical signal is visible of approx. 5µVpp amplitude.

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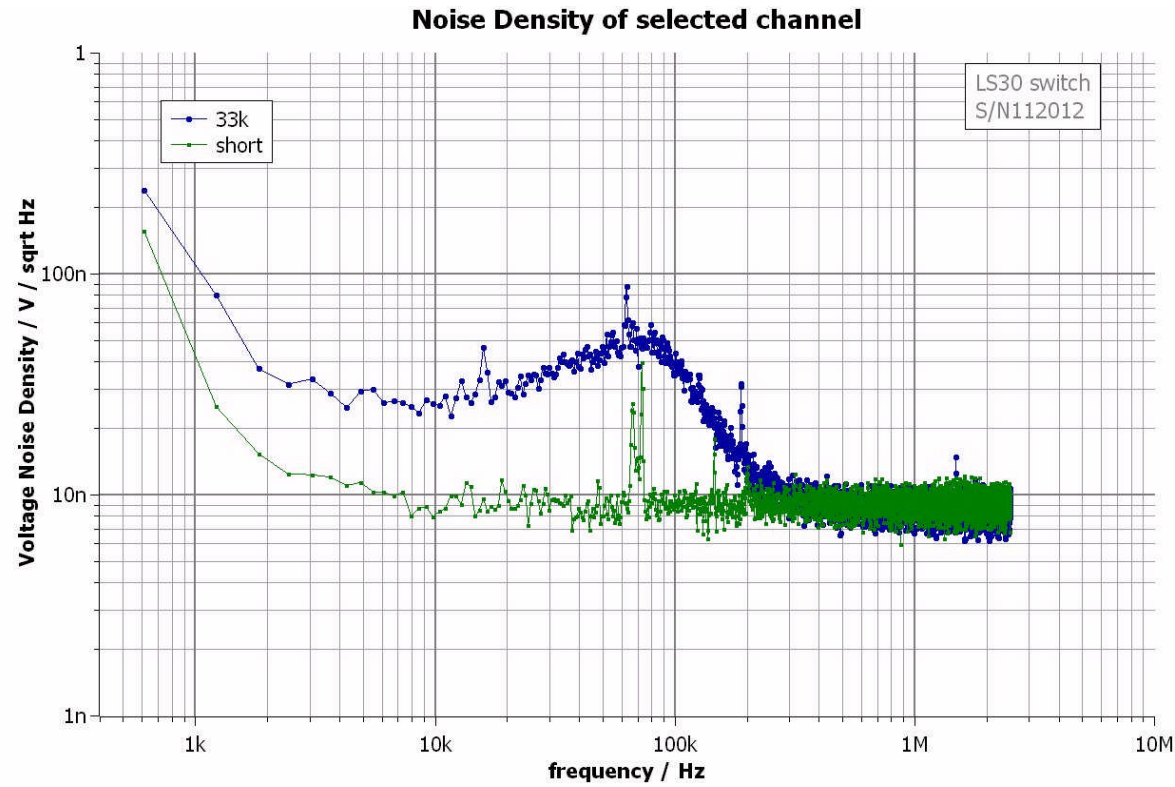

fig. 4.8: Wide band voltage noise density (600 Hz to 2.5MHz) observed at output, while input being switched to GND, i.e. shorted (lower trace, green) or connected via 33kOhms to GND (upper trace, blue). Measurement device: PicoScope3224 in FFT mode with x80 preamplifier. The green curve is essentially flat, corresponding to an underlying level of approx. 9nV/√Hz, while the green trace related to a 33kOhm termination is higher due to the thermal noise of the 33kOhm resistor (expected: 24nV/√Hz) and other parasitic current noise contributions.

5. Maintenance

The LS-30 switches are designed for years of reliable operation. Under normal operating conditions, they should not require electrical maintenance, except routine cleaning of dust. Exchange of ventilation fan is strongly recommended every 50'000 operation hours (see below). If any question should arise, please contact the manufacturer.

Routine cleaning

All ventilation openings should be checked periodically and kept free of dust and other obstructions. A vacuum cleaner may be used to clean these vents when the unit is powered off. The front panel may be cleaned periodically with a clean cloth and mild alcohol solution, when the unit is powered off. It is recommended to send the device to the manufacturer routinely in 4-year intervals for internal cleaning from dust.

Fan life time and temperature monitoring

The air ventilation fan is a part which shows unavoidable deterioration in time. Exchange of this part is strongly recommended after 50´000 hours of operation. Please contact manufacturer for replacement. Complete failure can lead to overheating of the device. Several temperature fuses and other protection measures provide a certain degree of safety against fire hazard in this case.

Fire hazard

Please note that excessive accumulation of dust inside the case of the device can lead to overheating. This, together with possible discharges increases the risk of fire, caused by electrical sparks. Routinely cleaning the device from dust minimizes this risk. It is therefore recommended to send the device to the manufacturer routinely in 4-year intervals for internal cleaning from dust, or to have it cleaned by an accordingly qualified electronical workshop. Also air conditions containing oil mists (e.g. in proximity to a vacuum pump or mechanical machines) place a severe danger, since inflammable substances could enter the device through the ventilation holes. If in doubt, cleaning by an accordingly qualified electronical workshop or the manufacturer is strongly recommended.
An increased hazard of fire may also occur if the device has been (permanently or temporarily) located in proximity to a strong (e.g. superconducting) magnet. A maximum external field of B = 10mT is admissible.

6. Specifications

Control Input			
	typ.	max.	Conditions and remarks
required drive level	0V and 5V	-2V to +6V vs. GND	
threshold	2.4V		
input impedance	1kΩ // 6pF		
Output Switch, static			
static resistance from A or B to OUT "on"-state	150Ω	180Ω	I_{OUT} < 50mA
isolation resistance from A or B to OUT	>50MΩ		voltage differences from A or B to OUT smaller or equal 15V
leakage currents from A or B to OUT	3nA	15nA	voltage differences from A or B to OUT smaller or equal 15V
intrinsic switch capacitance on OUT terminal	25pF to 35pF		
Noise	< 10µV_{rms}		DC to 20MHz
Transfer characteristics			
delay from control input change to output reaction	160ns		30V output step size (positive or negative going)
delay jitter	1ns rms		T = 25°C +/-1°C
max. pulse duration		infinite	
min. pulse duration	0		
Output rise or fall time, 10% to 90% step size	22ns		capacitive load of 100pF
Input Voltage Rating			
Input A or B vs. GND		+/-15V	both polarities may be applied vs. GND
Fuse rating	200mA medium-fast		fuse replaceable on rear side
Environmental Conditions			
Magnetic Field		max. 10 mT	B_{max} must never be exceeded
Storage Temperature		-55 C° to +85 C°	
Operating Humidity & Temperature	noncondensing relative humidity up to 95% between temperatures of +10°C and +35°C.		
Power Supply	AC input voltage 230V_{AC} at 50Hz. The power entry module is EMI/RFI-filtered. Fuse: medium fast blow 1.0A		
Power Consumption	3.4W		
Case dimensions	19.00" wide x 10" deep x 1 height unit. Front-panel mounting holes are configured for M6 rack configurations weight approximately 1.2kg		

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DECLARATION OF CONFORMITY

Manufacturer's Name: **Dr. Stefan Stahl**
- Electronics for Science and Research -

Manufacturer's Address: **Kellerweg 23**
67582 Mettenheim
Germany.

Declares, that the product

Product Name: **fast Low-Noise Signal Switch LS-30**
Model Number: **LS-30**

Product Options: **This declaration covers all options of the above product(s)**

Conforms with the following European Directives:

The product herewith complies with the requirements of the:

1. Low Voltage Directive 73/73EEC;

2. EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly

Date Of Issue

18. Sept. 2012

General Director

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